



Predicting Currents in the Straits of Mackinac with the Great Lakes Coastal Forecasting System

Great Lakes Coastal Forecasting System (GLCFS): Next Generation

NOAA's Great Lakes Coastal Forecasting System (GLCFS) is a set of three-dimensional hydrodynamic computer models that are designed to predict the physical environment of the lakes and connecting channels in a real-time nowcast and forecast mode. These models provide the public and decision makers with information on currents, water temperatures, short-term water level fluctuations (e.g. seiche, storm surge), ice, and waves for up to 120 hours into the future. Forecasts of the physical environment support several critical needs in the Great Lakes such as navigation, search and rescue, beach management, recreational use, and contaminant transport. The next generation of the Great Lakes Coastal Forecasting System is being developed through collaboration between NOAA's Great Lakes Environmental Research Laboratory (GLERL), Office of Coast Survey, and Center for Operational Oceanographic Products and Services (COOPS). The new GLCFS will expand the forecast coverage to important connecting waterways such as the Straits of Mackinac and increase nearshore resolution in order to predict beach-scale processes.

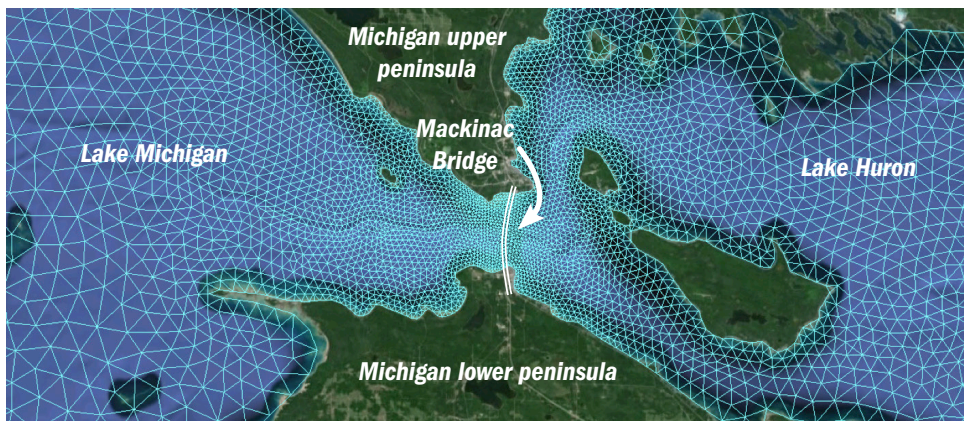


Figure 1: Hydrodynamic computer model grid of the Straits of Mackinac, part of the combined Lake Michigan-Huron model in the next generation of the Great Lakes Coastal Forecasting System.

Flow in the Straits of Mackinac

The new GLCFS includes the Straits of Mackinac, the connecting waterway between Lake Michigan and Lake Huron (Fig. 1). Due to meteorological conditions and the shape of the lakes, the Straits of Mackinac can experience currents up to 1 m/s that oscillate over the period of a few days (Fig. 2). This oscillation drives the water exchange between the lakes. Knowing the dynamics here is important as they play a role in water quality and in tracking the transport of contaminants.

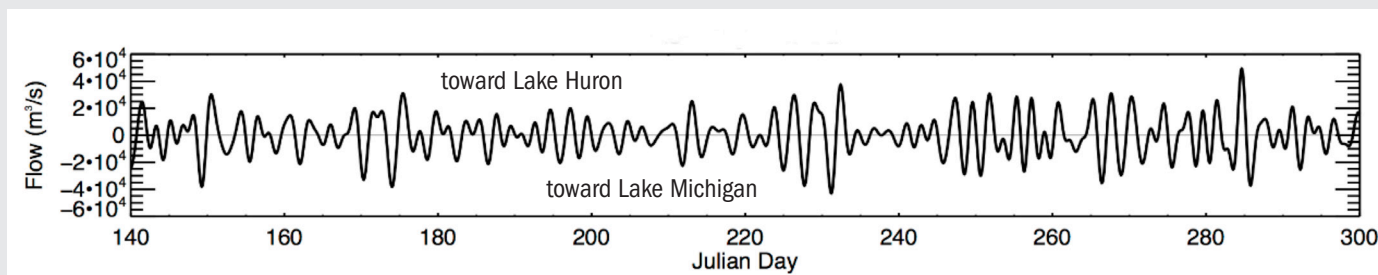


Figure 2: Oscillating exchange flow between Lake Huron and Lake Michigan (1990; positive is toward Huron, negative is toward Michigan; Anderson and Schwab, 2013).

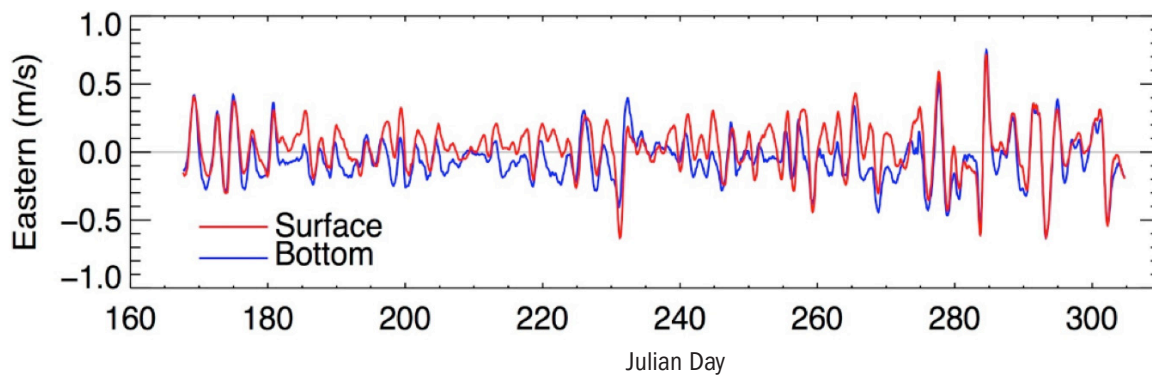
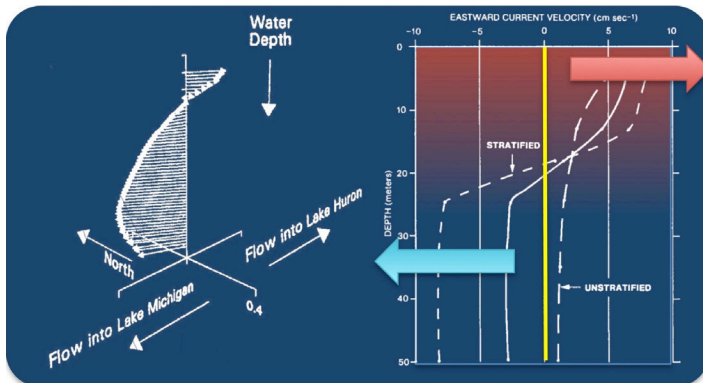


Fig. 3. Bi-directional currents at the Straits of Mackinac as a function of Julian day (1990) develop during the stratified period (approx. day 180 – 275; shown for east-west currents). Surface waters (warm) tend to deliver water from Michigan to Huron, with subsurface (colder) water returning from Huron to Michigan (Anderson and Schwab, 2013; Saylor and Miller, 1991).



As a result of the dynamic nature of the currents in the Straits of Mackinac, exchange between the lakes and transport of materials or contaminants is a complex process. With the development of the new GLCFS, this gap in forecast capability will be filled and finally provide guidance and understanding in one of the most critical areas of the Great Lakes.

Using interpolated meteorology, the new GLCFS model is able to predict flow in the Straits of Mackinac for the first time as part of a real-time forecast system. Analysis of the weather conditions and exchange flow between the lakes reveal a Helmholtz mode that exists within the combined Lake Michigan-Huron system and is responsible for the 3-day period of flow oscillation. During the summer months, when thermal stratification develops, the Straits also experience a bi-directional flow profile in which the warm surface water from Lake Michigan is transported to Lake Huron and a return flow of cold subsurface water from Lake Huron flows back into Lake Michigan (Fig. 3).

References

Anderson, E.J., and D.J. Schwab, 2013. Predicting the oscillating bi-directional exchange flow in the Straits of Mackinac. *Journal of Great Lakes Research* 39:663-671.
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<http://www.glerl.noaa.gov/pubs/fulltext/1991/19910004.pdf>



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